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Association between Sleep hours and Osteoporosis in middle aged and elderly Koreans

중년이상 한국인의 수면시간과 골다공증과의 관련성

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서 지 수

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서 지 수

서지수의 석사학위논문을 인준함

2014 년 2 월

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Abstract

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Background: Osteoporosis affects the bones, increasing the risk of fracture and mortality among middle aged and elderly people. There are many researches between risk factors and osteoporosis but it is difficult to find about the sleep hours and osteoporosis. This study was to determine the association between sleep hours (hours per night) and osteoporosis among middle aged and elderly people.

Methods: Among 2,844 middle aged and elderly people(1,223 male, 1,621 female) who participated in 2010 National health and nutrition examination survey. The participants were divided into six groups according to their self-reported average sleep hours per night.(≤4,5,6,7,8,≥9). Osteoporosis is defined as clinically diagnosed cases only. Logistic regression analysis was conducted to explore the association between sleep hours and osteoporosis.

Results: Those who slept 4 hours or less were more likely to have osteoporosis(OR=3.08, 95% CI: 1.73-5.45) than those who slept more than 9 hours. Factors such as gender, age and familial history of osteoporosis were significantly associated with osteoporosis.

Conclusion: This study shows that those who slept 4 hours or less seems to increasing risk odds of osteoporosis compared to longer sleepers(≥9 hours), therefore sleep hours seem to be an important factor for osteoporosis and providing longer sleep hours is recommended to prevent for osteoporosis.

Key words: Osteoporosis, sleep hours, chronic disease, fracture, middle aged people,stress
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Chapter Ⅰ. Introduction

1. Background

Degenerative diseases are on the rise in proportion to the increasing average life expectancy. As one of the most common metabolic bone diseases, osteoporosis is a condition characterized by significantly lower bone mass in comparison to that in normal people matched by age and gender(Hall et al,1991). With the ageing population, osteoporosis has been increasing sharply. According to the 2008 National Health and Nutrition Survey, 19.3% of the patients with osteoporosis in local communities are aged above 50 years old. In particular, domestically, the prevalence of osteoporosis in women aged above 50 years old accounts for 32.6%, which is 6-fold higher than 4.9% in men. According to the analyses of the Health Insurance Assessment and Claim data with a view to examining the aspects of using healthcare service among patients with clinically diagnosed osteoporosis, the number of patients (above 50 years old) with clinically diagnosed osteoporosis per year was 1.07 million in 2005, 1.2 million in 2006, 1.33 million in 2007 and 1.46 million in 2008(Health Insurance Review&Assessment Service,2010).As such, the rapid growth in the prevalence of osteoporosis needs attention in that it directly leads to higher medical expenses. Unlike other diseases, osteoporosis in its early stage is asymptomatic and subclinical, whereas once it develops complications, e.g. bone fracture, it is difficult to treat and associated with severe sequela and even death. Hence, not only therapeutic but also preventive generally known risk factors of osteoporosis measures are required to deal with osteoporosis.

Sleep accounts for a third of human life and has become considered an important element in modern society, where sleep deprivation is commonplace. Sleep deprivation, or reduced sleep hours, is associated with the advancement of electricity and machine, which has enabled individuals to extend their activity hours and to choose their own sleep hours.

According to the 2005 National Health and Nutrition Survey, the percentage of adults aged above 19 years old and sleeping 7-8 hours a day decreased from 58.8% in 1998 to 53.1% in 2005, where the mean sleep hours per day were 6.85 hours(KNHANES Statistical Information Service,1998; KNHANES,2005). Such reduction in sleep hours has been reported to be associated with obesity(Gangwisch et al,2005; Kohatsu et al,2006), death(Kripke et al,2002), hypertension(Gangwisch et al,2006), diabetes(Ayas et al,2003), cardiovascular disorders(Ayas et al,2003), falls and bone mass(Katie et al,2006) as well as with the quality of life. Also, a domestic study has reported that the incidence rates of hypertension and diabetes are higher in adults who sleep less than 5 hours than those who sleep more than 7 hours(Kim et al,2010).

A study on the relation between sleep hours and chronic diseases has found that sleeping less than 6 hours is a risk factor for developing chronic diseases, especially stroke and cancer(KNHANES Statistical Information Service,2005). It is well known that decrease in sleep hours is deeply related with obesity, hypertension, diabetes and cardiovascular diseases, respectively. Yet, the relation between sleep deprivation and osteoporosis has not been elucidated. Since the 1990s, studies on qualitative aspects of sleep and sleep hours have been gradually increasing. Reduced sleep hours have been reported to affect not only the quality of life but also chronic diseases e.g.

hypertension and diabetes as well as even osteoporosis. Diabetes increased the risk of osteoporosis and fracture (Hamann, C et al,2011). Likewise, The Korean Society of Menopause analyzed the relation between bone density and cardiovascular diseases among 1,643 menopausal women and found those who had hyperlipidemia were prone to a 2.1-fold higher risk of diagnosed osteoporosis and that neutral fat level was 115 mg/dl in those without osteoporosis in contrast to 127mg/dl in those with osteoporosis(Kim MR et al,2008).

A cross-sectional study on adults aged above 50 years old in Japan has found that the risk of osteoporosis is higher in those who sleep more than 8 hours than in those who sleep less than 6 hours(Kobayashi et al,2012). By contrast, another study on 600 Chinese women aged 18-80 years old has reported that bone density is lower in those who sleep less than 5 hours than in those who sleep more than 8 hours, which is more predominant in middle-aged and elderly females(Fu X et al,2011). Also, a study on 336 4-12-year-old children in the U.S. has demonstrated that longer sleep hours are positively correlated with bone health and that sleeping less than 8 hours influences decrease in bone mass(Casazza et al,2011). On the contrary, a study on white females aged above 69 years old has proved that the longer the sleep hours, the higher the risk of falls and pelvic fracture(Katie et al,2006). A study conducted in Wisconsin Medical School in the U.S. on field mice has found that the bone marrow density decreases in mice subjected to 72-hour sleep deprivation. (Carol et al,2012).

The overseas literature reviewed above does not show any consistent results regarding how osteoporosis is associated with sleep hours. Likewise, many domestic studies have delved into the relation between sleep hours and chronic diseases, e.g. hypertension and

diabetes. Nevertheless, it is hard to find any studies on how sleep hours are associated with osteoporosis, which warrants future research. In that sense, the present study is to identify the relation between osteoporosis and sleep hours in terms of gender, age and other factors influencing the sleep hours of domestic adults, ultimately to suggest some basic data applicable to seeking potential risk factors associated with osteoporosis.

2. Objective

This study focuses on the middle-aged and older Korean respondents in the 2010 National Health and Nutrition Survey (2010 KNHANES) to shed light on the factors related to sleep hours, the relation between sleep hours and osteoporosis and whether sleep hours can serve as a potential risk factor in osteoporosis and to contribute to preventive measures for osteoporosis.

To be specific, this study aims to find sleep hours and osteoporosis to see the confounding variables(socio-demographic variables, health status and health behavior) to analyzing the association between sleep hours and osteoporosis.

Chapter Ⅱ. Methods

1. Study population

This study used data from KNHANES Ⅴ(2010), which is conducted starting from 1998. These surveys are representing the general Korean population and including comprehensive health information on socio-demographics, health status and health behavior. Survey subjects include self reported to their questions and interviews at each participant's house and they were conducted by trained interviewers to gain health information. Each participant gave informed consent before participating in the studies.

In this study, used the 2010 KNHANES data and focused on middle aged and elderly people who completed health surveys. According to the previous study the prevalence of osteoporosis is shown to be rapid increases in the population above the age of 50 years(Cawston et al,2012). So population of less than 50 years was excluded in this study, and therefore, the total population in this study is 2,844.

2. Measures

ⅰ) Exposure and Outcome

The terminology used in this study is based on the 2010 National Health and Nutrition Survey, specifically the health-related questionnaire items in the first year of the 5th period. The participants were divided into six groups according to their self-reported average nightly sleep hours: ≤4,5,6,7,8,≥9 hours of sleep. The responses to the question item 'How many hours do you usually sleep a day?' in the National Health and Nutrition Survey are used as the sleep hours for this study. The incidence of osteoporosis is defined as clinically diagnosed cases only.

ⅱ) Confounding factors

From the data which was collected health information about various factors affects with the risk of osteoporosis. The present study analyses the relation between sleep hours and osteoporosis in view of socio-demographics, health status and health behavior, where sleep hours and osteoporosis are set as independent and dependent variables, respectively. Here, the control variables affecting the independent and dependent variables include socio-demographics, health status and health behavior. First, socio-demographic factors were including age(50-59, 60-69,and ≥70years), gender, education level(elementary school or under, middle school, high school, college education or more), income level(low,low-middle,high-middle,high), marital status(living with spouse, living without spouse), area of residence(urban, rural). Second, health status factors were including

familial history of osteoporosis, hyperlipidemia, diabetes and rheumatoid arthritis. Thrid, health behavior risk factors included smoking(smoker, non-smoker), alchol consumption(nondrinker, some of the time, always drinking), weekly physical activity(inactive, mild, moderate), stress(severe, some of the time, almost none of the time, mild), calcium intake(tertiles: <308, 308-542, and >542 mg/day), vitamin D blood level(tertiles: <15.6, 15.6-21.4, and >21.4ng/ml).

Socio-demographic variables are known to serve as risk factors for osteoporosis and affecting other chronic diseases as well (Allali et al,2010). Likewise, the lower the socioeconomic status, the higher the risk of fracture and the lower the BMD levels (Navarro et al,2012).

Health-status factors include the familial history of osteoporosis, hyperlipidemia, diabetes and rheumatoid arthritis. Sleep disorder is considered to increase the incidence of diabetes by dropping oxygen saturation and inducing secretion of cortisol, a stress hormone(Korean Diabets Association, 2012). The present study sub-categorizes the health status into the presence/absence of familial history of osteoporosis and the history of hyperlipidemia, diabetes and rheumatoid arthritis.

The health behavior includes smoking, drinking, physical activity, perceived stress levels, blood vitamin d levels and daily calcium intake. Here, smoking refers to lifetime smoking or non-smoking from the health-related question item in the National Health and Nutrition Survey, and is based on 5 packs (100 cigarettes). '5 packs or less' and 'Never smoked' are categorized into 'non-smokers,' while 'more than 5 packs' into 'smokers'(WHO). Smoking reduces bone density while increasing the risk of fracture in proportion to age (Kanis et al,2005). Drinking is categorized based on the frequency of drinking over a year. Excessive drinking was also an importance risk

factor associated with fracture, and was found to greatly increase the risk of femoral fracture and the risk of spine in males (Felson et al,1995). Physical activity is categorized based on the number of walking days in a week. The effects of physical activity reduce the risk of chronic diseases depending on the degree of activities and decrease the risk of injuries associated with fracture and fall (Province et al,1995). Vitamin d levels affect fall the risk of fracture. A lower level of serum vitamin d in the aged was found to lessen the grip strength and muscle mass(Visser et al,2003). Regarding calcium intake, most previous studies concluded that calcium intake was an important determinant of bone mass, but its effect was small(Welten et al,1995). Nonetheless, intake of calcium supplement reduced the risk of fracture by about 12%, indicating a positive effect on bone-density treatment(Tang et al,2007).

3. Statistical analysis

This study was conducted frequency analysis to assess the characteristics of the participants. The chi-square test was used to identify difference between sleep hours and the categories of independent variables. Logistic regression analysis was used to identify significance of difference between osteoporosis and independent variables.

Next, the logistic regression analysis(adjusted for socio-demograpic, health status, health behavior) was used to identify the relation between sleep hours and osteoporosis. All statistical analyses were performed using the Statistical Package for the Social Sciences version 21.0(SPSSWIN 21.0), with a 0.05 level of significance.

Chapter Ⅲ. Results

1. General characteristics

Table 1 shows the socio-demographic and health related characteristics of the study population from 2010 KNHANES. Difference between two groups of osteoporosis and non-osteoporosis were according to socio-demographic, health status and health behaviors. First, in socio-demographic variables, there were more females than males in both group. The group with 50-59 years old, 60-69 years old, and above 70 years old was 20.6%, 36.3%, 43.1% respectively in osteoporosis group. Slightly more than half of the participants were low level of education and the group with low level of income was highest in both group. Those who live with spouse were more than living without their spouse and living in urban were more than rural area in both group.

Second, in health status, those who had familial history of osteoporosis were higher than non-osteoporosis. The osteoporosis group whose morbid state of hyperlipidemia, diabetes and rheumatoid arthritis was higher than non-osteoporosis group.

Third, in health behavior smoking, drinking, physical activity stress, calcium intake and vitamin D blood level were measured. In terms of smoking, lifetime non-smokers outnumber smokers in both group. 'Some of the time' in drinking and 'moderate' in physical activities which is the highest percentage in both group. Regarding the perceived stress levels in osteoporosis group, 'Severe' and 'Some of the time' are higher than non-osteoporosis group. Blood vitamin d blood level is highest (36.0%) in the 3rd tertile, which is hardly

different from those in the 1st and 2nd tertiles in osteoporosis group. The calcium intake is highest (40.4%) in the 1st tertile, which is hardly different from those in the 2nd tertiles in osteoporosis group. Otherwise, the calcium intake is highest (35.6%) in the 3rd tertile, which is hardly different from those in the 1st and 2nd tertiles in non-osteoporosis group.

Table1. Socio-demographic and health related characteristics of the study population(n=2844)

variables	Total=2844				p-value
	Osteoporosis (n=383)		Non-Osteoporosis (n=2461)		
	n	%	n	%	
Age					***<0.001
50-59	79	20.6	991	40.3	
60-69	139	36.3	816	33.2	
≥70	165	43.1	654	26.6	
Gender					***<0.001
Male	29	7.6	1194	48.5	
Female	354	92.4	1267	51.5	
Education					***<0.001
≤Elementary School	266	70.2	1159	47.9	
Middle School	49	12.9	444	18.3	
High School	47	12.4	558	23.0	
≥College	17	4.5	261	10.8	
Income					***<0.001
Low	178	47.1	758	31.2	
Low-middle	83	22.0	616	25.4	
High-middle	63	16.7	512	21.1	
High	54	14.3	543	22.4	
Marital Status					***<0.001
With Spouse	248	64.8	1978	80.4	
Without Spouse	135	35.2	483	19.6	
Residence					0.334
Urban	264	68.9	1755	71.3	
Rural	119	31.1	706	28.7	
Familial history of Osteoporosis					***<0.001
Yes	85	22.2	340	13.8	
No	298	77.8	2121	86.2	

Hyperlipidemia					***<0.001
	Yes	99	26.1	388	16.0
	No	280	73.9	2036	84.0
Diabets					0.285
	Yes	63	16.6	343	14.2
	No	316	83.4	2081	85.8
Rheumatoid arthritis					***<0.001
	Yes	32	8.4	85	3.5
	No	347	91.6	2339	96.5
Smoking					***<0.001
	Non-Smoker	330	86.6	1352	55.6
	Smoker	51	13.4	1078	44.4
Drinking					***<0.001
	None	62	27.6	409	21.2
	Some of the time	136	60.4	953	49.4
	Always	27	12.0	566	29.4
Physical activity					0.083
	Inactive	92	24.1	472	19.4
	Mild	89	23.4	640	26.3
	Moderate	200	52.5	1318	54.2
Stress					0.073
	Severe	22	5.8	94	3.9
	Some of the time	85	22.3	448	18.4
	Almost none of the time	192	50.4	1332	54.8
	Mild	82	21.5	556	22.9
Vit.D[1)]					0.199
	1st tertile	121	35.2	748	32.8
	2nd tertile	99	28.8	767	33.7
	3rd tertile	124	36.0	763	33.5
Calcium intake[2)]					***<0.001
	1st tertile	143	40.4	719	32.0
	2nd tertile	126	35.6	729	32.4

	3rd tertile	85	24.0	799	35.6

*p<.05

**p<.01

***p<.001

1) Vitamin D blood level: <15.6, 15.6-21.4, and >21.4 ng/ml

2) Daily Calcium intake: <308mg/day, 308-542 mg/day, and >542mg/day

2. Characteristics of self-reported average sleep hours

Table 2 shows the charateristics of self-reported average sleep hours per night.. The participants were divided into six groups according to their self-reported average sleep hours.

First, socio-demographically, the percentage of those who sleep 4 hours or less is highest in those aged above 70 years old(11.2%), followed by 60-69(6.7%) and 50-59(4.5%). In terms of gender, the percentage of those who sleep 4 hours or less is higher in females (8.4%) than in males (5.5%), whereas the percentages of those who sleep 7hours and 8 hours are higher in males than in females. In education, the percentage of those who sleep 4 hours or less is highest in those who finished below elementary level (9.8%), followed by middle-school graduates(5.7%), high-school graduates(3.5%) and tertiary level and above(4.3%). In regard of income levels, the percentage of those who sleep 4 hours or less is highest (10.4%) in the lowest income earners, whereas it is lowest (4.4%) in the highest income earners. In the marital status, the percentage of those who sleep 4 hours or less is higher in those who do not live with their spouses (12.8%) than in those who do (5.6%). Concerning residential areas, the percentage of those who sleep 4 hours or less is 7.1% in urban areas and 7.2% in rural areas, where the difference is negligible. The percentages of those who sleep 8 hours are 23.0% and 20.1% in rural and urban areas, respectively. In short, all the socio-demographic aspects show significant differences in line with sleep hours.

Second, in terms of health status, those with familial history of

osteoporosis account for 9.0% of those who sleep 4 hours or less in comparison to 6.8% in those with no familial history of osteoporosis. Those with incidence of hyperlipidemia, diabetes and rheumatoid arthritis account for the highest percentage of those who sleep 4 hours or less. In brief, in health status, the incidence of diabetes shows significance differences in line with sleep hours.

Third, in terms of health behavior, the percentage of those who sleep ≤4 hours is lower in smokers (5.9%) than in non-smokers(7.9%). Simply put, smokers sleep longer hours than non-smokers. In drinking, the percentage of those who sleep 4 hours or less is highest in non-drinkers (7.6%), followed by 'occasionally' (6.2%) and 'frequently' (6.1%). In physical activities, the percentage of those who sleep 4 hours or less is highest (9.2%) in 'inactive' followed by mild(7.1%) and moderate(6.4%). Notably, the percentage of those who sleep 7 hours is highest (26.1%) in 'moderate.' Concerning perceived stress levels, the percentage of those who 4 hours or less is highest in 'severe'(30%) followed by 'some of the time'(11.4%). The percentages of those who sleep 7hours and 8 hours are relatively higher in 'almost none of the time' and 'mild.' In view of blood vitamin d levels, the percentages of those who sleep 4 hours or less and 5 hours are highest in the 1st tertile with 8.2% and 16.5%, respectively. In calcium intake, the percentages of those who sleep 4 hours or less and 5 hours are highest in the 1st tertile with 8.1% and 17.8%, respectively. The percentage of those who 4 hours or less is higher (12.1%) in clinically diagnosed osteoporosis cases than in the undiagnosed (6.4%). The percentage of those who sleep 7 hours and 8 hours are higher in those who have not been diagnosed with osteoporosis than those who have. These findings indicate that those who have been diagnosed with osteoporosis sleep less. In light

of the health behavior, smoking, perceived stress levels, blood vitamin D levels and daily calcium intake as well as diagnosed osteoporosis lead to significant differences in line with sleep hours.

Table2. Characteristics of self-reported average sleep hours(hours per night)

Variables	Reproted average sleep hours(hours per night)							p-value
	≤4	5	6	7	8	≥9	Total	
No.of subjects	201(7.2)	421(15.0)	676(24.0)	709(25.2)	588(20.9)	216(7.7)	2811	
Age								***<0.001
50-59	48(4.5)	124(11.7)	300(28.2)	292(27.4)	240(22.6)	60(5.6)	1064(100.0)	
60-69	63(6.7)	159(16.8)	224(23.7)	226(23.9)	206(21.8)	68(7.2)	946(100.0)	
≥70	90(11.2)	138(17.2)	152(19.0)	191(23.8)	142(17.7)	88(11.0)	801(100.0)	
Gender								***<0.001
Male	67(5.5)	139(11.5)	279(23.0)	321(26.5)	295(24.4)	110(9.1)	1211(100.0)	
Female	134(8.4)	282(17.6)	397(24.8)	388(24.3)	293(18.3)	106(6.6)	1600(100.0)	
Education								***<0.001
≤Elementary School	139(9.8)	249(17.5)	306(21.5)	334(23.4)	251(17.6)	146(10.2)	1425(100.0)	
Middle School	28(5.7)	57(11.6)	120(24.3)	142(28.8)	118(23.9)	28(5.7)	493(100.0)	
High School	22(3.6)	85(14.0)	160(26.4)	155(25.6)	156(25.8)	27(4.5)	605(100.0)	
≥College	12(4.3)	26(9.4)	87(31.3)	77(27.7)	63(22.7)	13(4.7)	278(100.0)	
Income								***<0.001
Low	96(10.4)	158(17.2)	185(20.1)	211(22.9)	174(18.9)	96(10.4)	920(100.0)	
Low-middle	42(6.1)	113(16.3)	159(22.9)	171(24.7)	157(22.7)	51(7.4)	693(100.0)	
High-middle	36(6.3)	60(10.5)	150(26.3)	165(28.9)	117(20.5)	43(7.5)	571(100.0)	
High	26(4.4)	86(14.5)	174(29.3)	153(25.8)	132(22.2)	23(3.9)	594(100.0)	
Marital Status								***<0.001

	Living with spouse	124(5.6)	305(13.8)	534(24.2)	569(25.7)	499(22.6)	180(8.1)	2211(100.0)
	Living without spouse	77(12.8)	116(19.3)	142(23.7)	140(23.3)	89(14.8)	36(6.0)	600(100.0)
Residence								
	Urban	142(7.1)	303(15.2)	512(25.7)	506(25.4)	400(20.1)	130(6.5)	1993(100.0)
	Rural	59(7.2)	118(14.4)	164(20.0)	203(24.8)	188(23.0)	86(10.5)	818(100.0)
Familial history of Osteoporosis								
	Yes	38(9.0)	62(14.7)	114(27.0)	102(24.1)	86(20.3)	21(5.0)	423(100.0)
	No	163(6.8)	359(15.0)	562(23.5)	607(25.4)	502(21.0)	195(8.2)	2388(100.0)
Hyperlipidemia								
	Yes	36(7.4)	81(16.6)	128(26.3)	112(23.0)	106(21.8)	24(4.9)	487(100.0)
	No	165(7.1)	337(14.6)	546(23.6)	596(25.7)	482(20.8)	190(8.2)	2316(100.0)
Diabets								
	Yes	43(10.6)	53(13.1)	87(21.4)	87(21.4)	97(23.9)	39(9.6)	406(100.0)
	No	158(6.6)	365(15.2)	587(24.5)	621(25.9)	491(20.5)	175(7.3)	2397(100.0)
Rheumatoid arthritis								
	Yes	9(7.7)	22(18.8)	27(23.1)	31(26.5)	21(17.9)	7(6.0)	117(100.0)
	No	192(7.1)	396(14.7)	647(24.1)	677(25.2)	567(21.1)	207(7.7)	2686(100.0)
Smoking								
	Non-Smoker	136(7.9)	280(16.3)	428(25.0)	426(24.8)	328(19.1)	117(6.8)	1715(100.0)
	Smoker	65(5.9)	141(12.9)	248(22.6)	283(25.8)	260(23.7)	99(9.0)	1096(100.0)

Drinking								0.391
	None	36(7.6)	77(16.3)	109(23.1)	108(22.9)	102(21.7)	39(8.3)	471(100.0)
	Some of the time	67(6.2)	150(13.8)	271(24.9)	292(26.8)	238(21.9)	71(6.5)	1089(100.0)
	Always	36(6.1)	81(13.7)	148(25.0)	163(27.5)	113(19.1)	52(8.8)	593(100.0)
Physical activity								0.074
	Inactive	52(9.2)	82(14.5)	132(23.4)	128(22.7)	117(20.7)	53(9.4)	564(100.0)
	Mild	52(7.1)	92(12.6)	196(26.9)	185(25.4)	151(20.7)	53(7.3)	729(100.0)
	Moderate	97(6.4)	247(16.3)	348(22.9)	396(26.1)	320(21.1)	110(7.2)	1518(100.0)
Stress								***<0.001
	Severe	12(10.3)	20(17.2)	31(26.7)	25(21.6)	21(18.1)	7(6.0)	116(100.0)
	Some of the time	61(11.4)	95(17.8)	128(24.0)	112(21.0)	102(19.1)	35(6.6)	533(100.0)
	Almost none of the time	86(5.6)	219(14.4)	381(25.0)	400(26.2)	330(21.7)	108(7.1)	1524(100.0)
	Mild	42(6.6)	87(13.6)	136(21.3)	172(27.0)	135(21.2)	66(10.3)	638(100.0)
Vit D								*0.031
	1st tertile	71(8.2)	142(16.5)	216(25.0)	195(22.6)	186(21.6)	53(6.1)	863(100.0)
	2nd tertile	51(5.9)	118(13.7)	220(25.5)	248(28.7)	169(19.6)	57(6.6)	863(100.0)
	3rd tertile	54(6.1)	125(14.2)	203(23.0)	229(26.0)	196(22.2)	75(8.5)	882(100.0)
Calcium intake								***<0.001
	1st tertile	69(8.1)	151(17.8)	179(21.1)	195(23.0)	179(21.1)	76(9.0)	849(100.0)
	2nd tertile	62(7.3)	130(15.4)	199(23.6)	231(27.3)	161(19.1)	62(7.3)	845(100.0)
	3rd tertile	53(6.0)	99(11.3)	239(27.2)	217(24.7)	207(23.5)	65(7.4)	880(100.0)

Osteoporosis								
	No	155(6.4)	341(14.0)	591(24.3)	618(25.4)	528(21.7)	197(8.1)	2430(100.0)
	Yes	46(12.1)	80(21.0)	85(22.3)	91(23.9)	60(15.7)	19(5.0)	381(100.0)

*p<.05

**p<.01

***p<.001

3. Logistic regression analysis of associated factors effected on osteoporosis

Table 3 shows the results of logistic regression analysis of socio-demographic effects on osteoporosis, where age and gender lead to significant differences. In terms of age, with the 50-59 being set as the reference 1, the OR(odd ratio) values are 2.34 in the 60-69 and 3.65 in the above 70 years old, indicating that the value is higher in those who are in their 70s. In terms of gender, females show a 13.69-fold higher risk than males. In education, college graduates and higher show the highest risk of osteoporosis (1.23 times). In income levels, the 'top' income earners show a low risk with 0.70 times. In marital status, those who do not live with their spouses show a lower risk of osteoporosis. In residential areas, rural areas show a 0.94-fold lower risk of osteoporosis than urban areas.

Table 4 shows the effects of health status on osteoporosis via logistic regression analysis. Familial history of osteoporosis, hyperlipidemia and rheumatoid arthritis show significant differences. Familial history of osteoporosis is associated with a 1.74-fold higher incidence of osteoporosis. Hyperlipidemia and rheumatoid arthritis show 1.84- and 2.57-fold higher risks of osteoporosis, respectively, compared with those who do not suffer from those diseases.

Table 5 concerns the result of logistic regression analysis regarding the effects of health behavior on osteoporosis. Smoking, drinking and perceived stress levels prove significant differences. In smoking, smokers show a 0.22-fold lower risk of osteoporosis than non-smokers. In drinking, some of the time and always drinkers show lower risks of osteoporosis than non-drinkers. In physical

activities, ‘mild’ and ‘moderate’ show lower risks of osteoporosis than ‘never’. In perceived stress levels, with ‘severe’ being set as the reference 1, ‘almost none of the time’ shows the lowest risk of osteoporosis (OR=0.40), which is statistically significant. In blood vitamin d levels, the 3rd tertile shows a 1.01-fold higher risk of osteoporosis than the 1st tertile. In calcium intake, the 3rd tertile shows a 0.73-fold lower risk of osteoporosis than the 1st tertile, which is statistically insignificant.

Table3. Socio-demographic associated with osteoporosis using logistic regression

	OR	p-value
Age		
50-59	1	
60-69	2.34(1.68-3.26)	***<0.001
≥70	3.65(2.56-5.22)	***<0.001
Gender		
Male	1	
Female	13.69(9.00-20.81)	***<0.001
Education		
≤Elementary School	1	
Middle School	1.05(0.73-1.52)	0.794
High School	0.95(0.65-1.39)	0.796
≥College	1.23(0.69-2.20)	0.489
Income		
Low	1	
Low-middle	0.79(0.58-1.08)	0.14
High-middle	0.82(0.58-1.16)	0.257
High	0.70(0.48-1.02)	0.065
Marital Status		
Living with spouse	1	
Living without spouse	0.86(0.66-1.13)	0.283
Residence		
Urban	1	
Rural	0.94(0.72-1.21)	0.614

Table4. Health status associated with osteoporosis using logistic regression

		OR	p-value
Familial history of Osteoporosis			
	No	1	
	Yes	1.74(1.33-2.28)	***<0.001
Hyperlipidemia			
	No	1	
	Yes	1.84(1.42-2.38)	***<0.001
Diabets			
	No	1	
	Yes	1.10(0.81-1.49)	0.544
Rheumatoid arthritis			
	No	1	
	Yes	2.57(1.67-3.93)	***<0.001

Table5. Health behavior associated with osteoporosis using logistic regression

	OR (95%CI)	p-value
Smoking		
Non-Smoker	1	
Smoker	0.22(0.14-0.33)	***<0.001
Drinking		
None	1	
Some of the time	0.94(0.65-1.35)	0.734
Always	0.45(0.26-0.80)	**0.006
Physical activity		
Inactive	1	
Mild	0.61(0.39-0.96)	*0.031
Moderate	0.66(0.45-0.97)	*0.035
Stress		
Severe	1	
Some of the time	0.48(0.24-0.96)	*0.038
Almost none of the time	0.40(0.21-0.76)	**0.005
Mild	0.53(0.27-1.04)	0.063
Vit D		
1st tertile	1	
2nd tertile	0.73(0.49-1.07)	0.107
3rd tertile	1.01(0.70-1.47)	0.952
Calcium intake		
1st tertile	1	
2nd tertile	1.10(0.76-1.59)	0.618
3rd tertile	0.73(0.49-1.09)	0.128

4. OR of osteoporosis using logistic regression analysis adjusted for variables.

Table6 shows the results of stepwise correction over socio-demographics, health status and health behavior affecting sleep hours and osteoporosis as a way to analyze the odds ratios of osteoporosis in line with sleep hours. Model 0 analyses the odds ratio of osteoporosis in line with sleep hours when socio-demographics, health status and health behavior are not corrected. In the odds ratio of osteoporosis in line with sleep hours with no correction applied, 4 hours or less and 5 hours of sleep exert significant effects on osteoporosis. Here, the odds ratio is highest (3.08) in 4 hours or less of sleep. Model 1 indicates that 4 hours or less, 5 hours and 7 hours of sleep have significant effects on osteoporosis, where the odds ratio of osteoporosis is highest (2.48) in 4 hours or less of sleep. Model 2 analyses the odds ratio of osteoporosis in line with sleep hours with socio-demographics and health status corrected, where 4 hours or less and 5 hours of sleep exerts significant effects on osteoporosis. The odds ratio of osteoporosis is highest (2.48) in 4 hours or less of sleep. Model 2 analyses the odds ratio of osteoporosis in line with sleep hours with socio-demographics and health status corrected, where 4 hours or less and 5 hours of sleep have significant effects on osteoporosis. The odds ratio of osteoporosis is highest (2.34 times) in 4 hours or less of sleep. Model 3 corrects socio-demographics, health status and health behavior and analyses the odds ratio of osteoporosis in line with sleep hours, where the odds ratio of osteoporosis is highest(1.81) in 5 hours of sleep, and lowest (1.25) in 8 hours of sleep, which is not statistically significant.

Table6. OR of osteoporosis using logistic regression analysis adjusted for variables

	MODEL 0		MODEL 1		MODEL 2		MODEL 3	
	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value
Reported average sleep hours (hours per night)								
≥9	1		1		1		1	
≤4	3.08(1.73-5.45)	***<0.001	2.48(1.34-4.59)	**0.004	2.34(1.26-4.36)	**0.007	1.56(0.61-3.99)	0.359
5	2.43(1.43-4.13)	***0.001	2.14(1.22-3.77)	**0.008	2.02(1.14-3.59)	*0.016	1.81(0.79-4.13)	0.161
6	1.49(0.88-2.52)	0.134	1.68(0.96-2.94)	0.07	1.58(0.89-2.78)	0.117	1.31(0.58-2.97)	0.519
7	1.53(0.91-2.57)	0.111	1.76(1.01-3.06)	*0.047	1.68(0.96-2.95)	0.071	1.35(0.60-3.02)	0.473
8	1.18(0.69-2.02)	0.553	1.57(0.88-2.80)	0.128	1.49(0.83-2.67)	0.186	1.25(0.54-2.92)	0.6

Model 0 (not adjusted)

Model 1 (adjusted for socio-demographic: age,gender, income, education,marital status, residence)

Model 2 (adjusted for socio-demographic, health status: familial history of osteoporosis, hyperlipidemia, diabetes, rheumatoid arthritis)

Model 3(adjusted for socio-demographic, health status, health behavior: smoking, drinking, physical activity, stress, calcium intake, vitamin D blood level)

Chapter Ⅳ. Discussion

The present study analyses the first-year data from 2,844 respondents in the 2010 National Health and Nutrition Survey to shed light on the relation between sleep hours and osteoporosis. Also, this study analyses the differences in sleep hours of the subjects in regard of their socio-demographic, health-status and health-behavior variables, and then investigates the effects of each variable on osteoporosis. Then, the logistic regression analysis is conducted on each variable factor so as to find out the relation between osteoporosis and sleep hours. Among those who sleep 4 hours or less, 12.1% are clinically diagnosed with osteoporosis, while 6.4% are not, equivalent to about a 2-fold difference. As the sleep hours increase, the incidence of osteoporosis tends to decrease. In terms of socio-demographic variables, the risk of osteoporosis is statistically significantly high in above 70 years old and females, which is consistent with the finding that age served as the most important factor affecting the bone mass(Riggs et al,1986). In health-status variables, the familial history of osteoporosis, diabetes and rheumatoid arthritis incidence increase the risk of osteoporosis. Literature on the relation between diabetes and fracture reported that regardless of bone-mass measurements, the risk of fracture increased in both type-1 and type-2 diabetes patients (Oh G.W.). As the health-behavior variables, both smoking and drinking as well as the perceived stress levels are statistically significant. Smokers show a 0.22-fold lower risk of osteoporosis than non-smokers, which finding disagrees with the report that smoking was associated with a high risk of fracture (Law & Hacjahaw,1997). In terms of drinking, ‘some of the time’ or ‘always’ drinkers show a lower risk of osteoporosis

than non-drinkers. Alcoholism is well known to have had negative effects on health (Sampson et al,2002), whereas moderate drinking increased bone density (Felson et al.,1995). Stress is a risk factor as well. Caring too much about something causes adrenocortical hormone to be secreted to the extent that calcium absorption reduces in the intestine leading to calciuria. In short, stress per se is risky.

As for the relation between osteoporosis and sleep hours, the risk of osteoporosis increases in those who sleep 4 hours or less and 5 hours compared with those who sleep 8 hours. Specifically, the risk of osteoporosis is about 3-fold higher in those who sleep 4 hours or less than those who sleep 9 hours. Even when both the socio-demographic and health-status variables are corrected, the less the sleep hours, the higher the risk of osteoporosis. In contrast, with socio-demographic, health-status and health-behavior being corrected, decrease in sleep hours statistically insignificantly increases the risk of osteoporosis. Similarly, a study on Chinese females found that females who slept 5 hours or less showed a lower bone density than those who slept over 8 hours, which was more predominant in middle-aged and elderly women(Fu X et al,2011). Also, a study on 4-12-year-old U.S. children found that longer sleep hours had positive correlations with bone health, which is consistent with the present findings(Casazza et al,2011). A study on field mice in the U.S. found that the bone-marrow density of mice that underwent a 72-day sleep deprivation decreased. These findings were ascertained through blood testing of osteocalcin, insulin-like growh factor 1(IGF-1)and plasma marker levels. If the same phenomenon occurs in humans, chronic sleep restriction could cause osteopenic bone leading to increased fracture risk, decreased bone healing after surgery and decreased bone development. Many of us face bone loss as we age

and its accompanying lack of sleep(Carol et al,2012). As we get older, it can be harder to get a good night's sleep. Because melatonin, an important horomone that affects sleep, decreases as we age. Lower melatonin levels and the subsequent decrease in sleep that come with aging could be silent partners, working together to accelerate bone loss(Vivian,2012). In other study, lack of sleep can worsen obesity and excess adipose tissue may alter bone mineral density. Obesity affects bone metabolism through weight loading and production of cytokines and hormones(Stefania Mariani et al,2012). In contrast, a cross-sectional study on adults aged above 50 years old in Japan found that the risk of osteoporosis decreased in those who slept over 8 hours than in those who slept 6 hours or less(Kobayashi et al,2012). A study on white females aged above 69 years old found that the longer the sleep hours, the higher the risk of osteoporosis, which is inconsistent with the present findings. There are differences in the effects of sleep hours on osteoporosis in this study, which seems attributable to the incidence of osteoporosis being limited to clinically diagnosed cases only and to the differences in age, race or socio-culture in the distribution of sleep hours.

The finding reported by the study conducted in Japan that longer sleep hours were associated with higher risks of osteoporosis seems ascribable to the study subjects being limited to the middle-aged and older women visiting a healthcare center of a general hospital in a certain area, who may have taken better care of their health than those adults who had not received such health checks. On the contrary, despite the smaller sample size than that of the Japanese study, the present study is meaningful in that it uses the data that represent Korea and that it analyses the relation between sleep hours and osteoporosis in an age group above 50 years old for the first

time. Although no biological mechanism between sleep hours and osteoporosis has been elucidated, lack of sleep increases insulin resistance and the speed of brain atrophy, which in turn induces stress and weakens immunity, affecting bone health and chronic diseases after all.

As for the limitations of this study, first, the cross-sectional approach cannot present the causal relations between sleep hours and osteoporosis. Still, the findings here support the previous reports that sleep hours served as a potential factor influencing bone health. Second, relying on the respondents' memory about their sleep hours, particularly at night time only, in the self-reported survey might have caused a recall bias. Also, such qualitative aspects of sleep as insomnia, hypersomnia and sleep apnea are not considered, which means that the present research does not evaluate the objective sleep quality.

Chapter Ⅴ. Conclusion

The present cross-sectional study delves into the relation between sleep hours and osteoporosis in middle-aged and elderly population(above 50 years old). From the first-year data of the 2010 National Health and Nutrition Survey, a total of 2,844 subjects are selected. Logistic regression analysis and a model are used to investigate the relation between sleep hours and osteoporosis. The model is corrected stepwise in line with socio-demographic, health-status and health-behavior variables to analyze odds ratios. Based on the analysis of odds ratios, when confounding variables are not corrected, the risk of osteoporosis is significantly higher in both those who sleep 4 hours or less and those who sleep 5 hours, by 3.08 and 2.43 times, respectively, in comparison to those who sleep more than 9 hours. With the socio-demographic variables being controlled, the risk of osteoporosis is significantly higher both in those who sleep 4 hours or less and those who sleep 5 hours by 2.48 and 2.14 times each in comparison to those who sleep more than 9 hours. With both socio-demographic and health-status variables being controlled, the risk of osteoporosis is in inverse proportion to sleep hours, which is statistically significant.

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국문초록

중년이상 한국인의 수면시간과 골다공증의 관련성

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연구배경: 수면시간과 만성질환과의 관련성에 관한 연구는 이전 연구들을 통해 잘 알려져 왔다. 중년이상에서의 골다공증은 뼈건강에 영향을 주며 골절의 위험 및 사망률의 증가로 이어지고 있다. 골다공증과 골다공증 위험요인들과의 연구들은 많이 행해져 오고 있지만 수면시간과 골다공증과의 연관성에 관한 연구는 부족한 실정이다. 이 연구에서는 중년이상을 대상으로 수면시간과 골다공증과의 연관성에 대해 알아보고자 한다.

연구방법: 본 연구는 2010 국민건강영양조사에 참여한 2,844명을 대상으로 한 단면연구를 시행하였다. 수면시간 측정은 6구간으로 나누었으며 (≤4, 5, 6, 7, 8, ≥9) 하루 평균 수면시간에 대한 자가보고기입 형식으로 시행하였으며 골다공증 유병여부는 의사로부터 골다공증 진단을 받은 경우로 구분하였다. 수면시간과 골다공증과의 연관성을 알아보기 위해 회귀분석을 시행하였다.

연구결과: 성별, 연령, 골다공증 가족력의 요인등이 골다공증에 유의한 관련성이 있었으며 하루에 4시간 이하 수면을 취하는 경우(OR: 3.08, 95% CI: 1.73-5.45) 9시간 이상 수면을 취하는 경우에 비해 골다공증의 위험도가 더 높았으며 골다공증 발생과 유의한 관련성이 있었다.

결론: 하루 평균 수면시간에 따라 골다공증의 위험도와 유의한 관련성이 있었으며 수면시간이 골다공증의 중요한 위험인자로 작용하므로 골다공증을 예방하기 위해서는 충분한 수면시간이 요구되어진다.

주요어: 골다공증, 수면시간, 만성질환, 골절, 중년인구, 스트레스
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